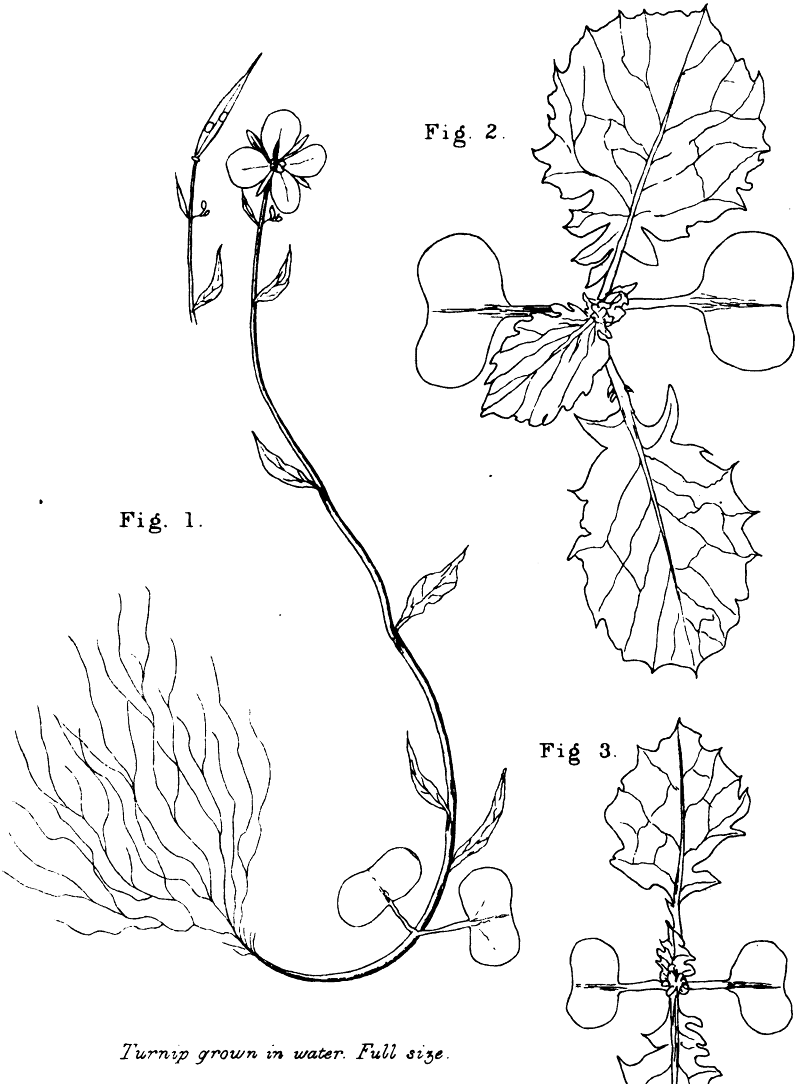

Turnip grown in water. Full size.

Fig 2 & 3. Turnips 23 days old. Full size.

Fig 2. From large seed.

Fig 3. From small seed.

McFarlane & Erskine Lithrs. Edinr.

IV. *Experiments with Turnip Seeds.* By A. Stephen Wilson. (Plate II.)

(Read 8th February 1877.)

The present paper contains the results of experiments proposed to be made by the writer, in a communication laid before the Botanical Society in January 1876. That communication detailed an experiment in which large and small seeds of Swedish turnip (*Brassica campestris rutabaga*) were grown in water, on opposite sides of the same plate, and in which the larger seeds produced the larger plants; suggesting the probability that a part of the difference in the sizes of contiguous bulbs in ordinary field culture is due to difference in the size of the seeds from which these bulbs have been produced. From certain experiments, Darwin has come to the general conclusion ("Cross and Self-Fertilisation of Plants," p. 353), that "it cannot be doubted that heavy and fine seeds tend to yield the finest plants."

A full discussion of the anatomy and physiology of the turnip, from the embryo to the flower, although very desirable in connection with these experiments, must for the present be deferred.

The common turnip of many varieties (*Brassica rapa*) as well as the Swedish turnip, are usually stated to be biennial plants. But a precise and unqualified statement of this kind is likely to mislead, inducing the conception that bienniality is essential to the existence of these plants. Now, whether a turnip shall be annual or biennial depends upon the circumstances under which it is grown, and perhaps also, in some cases, upon inherited tendencies. A look across the fields or gardens, almost any season, will reveal here and there a plant running to seed. If such a plant is examined, it will usually be found to have a small or defective bulb. The law therefore seems to be, that if bulbing is prevented, annuality is secured. While if the leaves and leaf-stalks which form the stems, are arrested below the insertion of the cotyledons, they will be fleshified and swelled out into a bulb, and the plant will be made biennial.

Some further experiments were made by the writer, of the same character as those detailed in his last paper. The saucer in which the plants were growing, in water, and the dust which fell upon them, was set aside in the window. The seeds were put into the water on 8th January (1876); many of them came into flower in June at a height of 3 or 4 inches, some of them ripening one seed and some two seeds, of nearly the ordinary size (Pl. II. fig. 1); not one of these saucer plants showed the least appearance of bulbing. Bulbing, therefore, is not an essential fact of the turnip, but a fact the cause of which may be inquired into, with the purpose of controlling that cause in a direction beneficial to agriculture.

In selecting the large and small seeds for these experiments, both sets were taken from the same parcels. Probably this is a condition of importance, because equal seeds from different stocks may have unequal tendencies to bulb. It is generally believed, that seed from transplanted turnips are productive of a heavier crop than seed from untransplanted. The seeds selected were the largest and the smallest unshrivelled seeds. They were not compared as to weight; but, as in my first experiment, the large seeds bore to the small the ratio of 100 to 59, a ratio near this may be taken as descriptive of the classes of seeds below.

Experiment 1.—On the 22d May, in newly dug ground in the garden, two rows of swedes, large and small, a single seed in each hole of an inch deep, were planted at distances 8 inches apart.

Except two plants, opposite each other, all the others were either completely eaten by the fly, or so much damaged as to be put out of competition. The blanks could have been filled up, but as this would have given plants grown at different dates, and with different length of life, the blanks were allowed to remain. The two bulbs which competed were pulled on the 8th January. The net weight from the large seed was 3 lb. 15½ oz.; from the small seed, 4 lb. 3 oz.

Experiment 2.—On the 24th May, in the field, 40 yards of two adjoining drills were planted with large and small Swedish seeds. Two or three seeds were put in each hole at distances intended to be 8 inches apart, but there were

180 holes on the small side and 170 on the large. The seeds were deposited an inch deep, on drills newly manured and closed and rolled down by the machine, with the seed boxes shut. The seeds in every hole germinated, but the young plants were severely handled by the fly. By the 8th June many were destroyed; so that wherever the plants appeared to be so much damaged as to make it unlikely that they would come through, the stumps were removed, and large seeds of yellow turnips put in the blanks of the large-seed drill, and small seeds of the same yellow turnips put in the blanks of the small-seed drill, for another experiment. On the 30th of June both swedes and yellows were singled by the hand, all weeds being pulled out, and the drills being left unreduced. They were singled on the principle of leaving the best plant in each hole; but in the case of the swedes, the fly in many instances had left but a single plant of the two or three which came up. Of the large-seed swedes, the fly left 67 per cent.; of the small, 58 per cent. When the singling had been finished, it was obvious to the eye that the large seeds had the advantage. Of these there were 66 per cent. of good fair plants; while of the small seeds there were of good fair plants but 41 per cent. Hardly any of the swedes had wholly escaped the fly. The sides of the drills were hoed a second time, and the weeds on the top pulled out, but the drills were not horse-hoed, nor the earth taken away from the bulbs. From various causes, such as insects, wind, &c., a few more of the plants were destroyed after singling, but no blanks were made up.

The swedes were pulled on the 20th January. The number of large seeds was 105; the gross weight 307 lb. 12 oz.; the net weight, 300 lb. 4 oz.; the average net weight was 2 lb. 13¾ oz. The heaviest bulb weighed 7 lb. 10 oz.; the lightest, 6 oz. The ten heaviest weighed 53 lb. 6 oz.; the ten lightest weighed 9 lb. 9 oz.

The number of small seeds was 108; the gross weight 267 lb. 9 oz.; the net weight 262 lb. 4 oz.; the average weight 2 lb. 6¾ oz. The heaviest bulb weighed 5 lb. 14 oz.; the lightest, 2 oz. The ten heaviest weighed 47 lb. 8 oz.; the ten lightest weighed 5 lb.

Experiment 2-A.—The green-top yellows, which were interplanted amongst these swedes, were also singled on the principle of leaving the best plants in both sets of seeds. They were pulled at the same time as the swedes, and there had survived thirty-nine plants from each size of seeds. Of the large seeds, the gross produce was 117 lb. 8 oz.; the net weight being 112 lb. 4 oz.; and the average net weight 2 lb. 14 oz. The heaviest bulb weighed 6 lb. 14 oz.; the lightest 12 oz. The heaviest ten weighed 48 lb. 6 oz.; the lightest, 14 lb. 15 oz.

Of the small seeds, the gross produce was 95 lb. 1 oz.; the net, 91 lb. 6 oz; the average weight of bulb 2 lb. 5½ oz. The largest bulb weighed 6 lb. 10 oz.; the smallest, 11 oz. The largest ten weighed 42 lb. 12 oz.; the smallest ten weighed 9 lb. 10 oz.

Experiment. 3.—In another part of the same field, on the 30th May, 17 yards of two adjoining drills, newly manured, closed and rolled, were planted with large and small Swedish seeds. The holes were about 9½ inches apart, and from four to six seeds were put in each. They were singled on the 26th June, leaving the best plant in each hole. On the whole, the large seeds had the larger plants, but it was clear that all the plants had not grown with anything like equal vigour, because it would have been easy by selection to have left larger plants of the small seeds than of the large; for by leaving the most forward plants of the small seeds, and the least forward of the large seeds, the small-seeded row could have been left with the best plants, at least for the time being; whether permanently or not is yet to be inquired. If a large-seed plant, although behind a small-seed plant at the time of singling, would ultimately outgrow the small seed plant, then the work of singling is thus far performed in the dark.

What, it may be asked, is the reason of the great diversity in size of young turnip plants growing in the same hole or tuft, not half an inch asunder? Various causes, singly and combined, are probably in operation. Of two plants deposited at the same depth, having the same relation to moisture and heat, and in the same position of growth, the larger seeded will have the larger cotyledons. But if, of two contiguous seeds, the one falls in such a position that for the first few days of germination the radicle is growing up into dry earth, while the other beside it lies in such a position that the radicle, when it breaks the shell, strikes right down into damp earth, the latter will necessarily be in advance of the former: whether its advantage in starting shall be maintained, depends on various circumstances. Again, the young radicle cannot go through a dry clod or a small stone. If the radicle of a large seed has to go round the corner of a dry clod or small stone before striking down, the plant of a small seed will gain the start, whose radicle meets with no such obstruction. Again, under equal moisture the seed planted at least depth will appear first; but if the shallow seed lies in a dryer bed, while the deep seed lies in a damp, the deep seed will appear first, and for a time, at least, seem the better plant. Sometimes, again, the cotyledons are held down by a bit of hard earth. I have seen a loop of the root pushed above the surface before the cotyledons were able to appear, which must retard the growth, and attenuate the root, as compared with the plant which gets more easily up into the atmosphere. And besides all these, there can hardly be any doubt that some seeds have in themselves a greater vegetative energy than others: some will germinate sooner than others on a damp cloth, where we can be apparently sure that all external conditions are equal.

It is thus seen that the theory of singling in such experiments as the present is by no means so simple as might be imagined. Of four or five large or small seeds dropt into a hole, one is probably larger than any of the others, and one smaller. In singling, the largest seeded and the smallest seeded plants should be left, but we do not know how to do it; and besides, unless the conditions of growth, internal and external, are equal in both cases, the experiment acquires complications which we are not yet able to interpret. Undoubtedly the little embryo which lies with its root rolled up in its two soft leaves has a definite constitution. In one case its cells may be prepared to go on multiplying till it can boast of a bulb of 8 pounds in weight; in another case some mysterious sterility may arrest the reproduction of cells before its bulb weighs 2 pounds; in another case the taint of disease may reduce it to a rotten mass. The great variety in size of bulbs on any field, which at present we cannot explain, shows that our botany has something to learn. The average turnip space over the country yields perhaps less than 2 pounds; and when we see many spaces yielding nothing, and many yielding 6 and 8 pounds, our science is called upon to examine the subject.

The swedes of experiment 3 were pulled on 29th November. Of large-seed plants there were 63, the gross weight of which was 136 lb. 8 oz.; the net weight, 126 lb. 3 oz; the average weight 2 lb. The heaviest weighed 4 lb. 12 oz.; the lightest, 3½ oz. The ten heaviest weighed 36 lb. 10 oz,; the ten lightest, 6 lb. 6 oz.

Of small-seed plants, the number was 55; the gross weight 76 lb. 9 oz.; the net weight 72 lb. 2 oz.; the average weight 1 lb. 5 oz. The heaviest weighed 3 lb. 6 oz.; the highest, 1 oz. The ten heaviest weighed 27 lb. 2 oz.; the ten lightest, 3 lb. 1 oz. These swedes were planted too late in the season.

Experiment 4.—Another set of swedes of a different sort (Shepherd's Golden Globe) were also planted on the 30th May, under the same conditions as in experiment 3. From four to six seeds were deposited about an inch deep in holes 9½ inches apart. The plants were singled by the hand on 29th June, leaving in both rows the largest healthy and whole plants. They were not touched by the fly. At the date of thinning, the larger seeds had the larger plants, although the difference was not conspicuous. In all cases the drills were left untouched, the weeds on the top being taken out by the hand. They were pulled on the 28th December. The large-seed plants numbered 54; their gross weight was 109 lb. 4 oz.: their net weight, 104 lb. 10 oz.; their average weight, 1 lb. 15 oz. The heaviest bulb was 4 lb. 7 oz.; the ten heaviest, 33 lb. 5 oz.; and the ten lighest, 7 lb. 15 oz.

The small-seed plants numbered 57; their gross weight was 108 lb. 1 oz.; their net weight, 102 lb. 5 oz.; their average weight, 1 lb. 12¾ oz. The heaviest bulb was 4 lb. 14 oz.; the ten heaviest, 29 lb. 15 oz.; the ten lightest, 7 lb. 11 oz.

Experiment 5.—In experiment 5, the seeds were golden yellow; large and small selected from the same sample. They were planted on 30th May, in newly manured and worked land, as in the above cases; the seeds being planted in holes at the same depth and distance apart. They were not touched by the fly. They were singled on 26th June, on the principle of leaving of the large-seeded plants, the plant in each hole having the broadest cotyledons; and leaving of the small-seeded plants, the plant in each hole having the smallest cotyledons,—all the plants left being whole and healthy.

This method of singling proceeded on the fact (previously ascertained) that the largest seed has the largest cotyledons, and the smallest seed the smallest cotyledons, or seed leaves; and on the assumption that all the seeds started in an even race of germination.

From the circumstance that in the ovary one cotyledon envelopes the other, the outer cotyledon is always largest. Neglecting the difference, the seed leaves of a large Swedish seed come to a size of ·9 of an inch across, and ·5 of an inch along the quasi midrib; the two cotyledons thus presenting an upper surface of ·90 of a square inch. The cotyledon of a small-seeded Swedish plant measures across ·6 of an inch, and along the midrib ·3, the two leaves thus measuring ·36 of a square inch. So that the cotyledonary surface of a small-seeded swede is two-fifths of the surface of a large-seeded. In yellow turnips again, the cotyledons from a large seed measure across, when fully developed, ·8 of an inch, and ·4 along the midrib, making the upper area of the two ·64 of a square inch. In the small seed the breadth of cotyledon is ·4 of an inch, and the length ·3; the two upper surfaces making ·24 of a square inch. Thus in the yellow turnip the ratio of cotyledonary surface presented to the atmosphere in large and small seeded plants is 100 to 37; and in the swede 100 to 40.

Of course these dimensions are merely of a typical character, the variations being infinite. But it is probably an important physiological fact, that the cotyledons of a small seed never grow to be so large as those of a large seed; they come to a certain limit and stop; they will not grow broader with longer time. The epigeal cotyledon of a turnip which expands into a green leaf, probably stands in a somewhat different biological relation to the plant from that of the hypogeal cotyledon of the pea, which simply yields up its store. This paper is not concerned with the functions of these organs, but it may be mentioned that they are such, that a turnip plant grown in water to a height of 3 or 4 inches, without flowering, and then thoroughly air-dried, is lighter than the seed from which it sprang.

The turnips of experiment 5 were pulled on the 28th December. Of the large seed there were 57; of which the gross weight was 167 lb. 6 oz.; the net weight, 150 lb. 12 oz.; the average weight, 2 lb. 10¼ oz. The heaviest bulb weighed 5 lb. 10 oz.; the ten heaviest weighed 44 lb. 14 oz.; and the ten lightest, 11 lb. 2 oz.

Of the small seed there were 58; having a gross weight of 131 lb. 4 oz.; a net weight of 120 lb.; and an average weight of 2 lb. 1 oz. The heaviest bulb weighed 4 lb. 7 oz.; the ten heaviest weighed 38 lb. 4 oz., and the ten lightest, 5 lb. 4 oz.

Experiment 6.—The seeds in this experiment were of the variety called Tweeddale purple-top. They were put in at the same time, in the same manner, and under the same conditions as in experiment 5. The plants were singled on the 19th June, upon the same principle as in the last case, namely, leaving of the large seed the plants with largest cotyledons, and of the small seed the plants with smallest cotyledons. There was no touch of fly. At this date the large seeds had decidedly the larger plants on the average before singling, although some of the smaller seeds had larger plants than the smaller plants of the large seed. The plants of the larger seeds were about 1½ inch across; the plants of the smaller seeds about ¾ of an inch.

During the day the young turnip lies broader and more expanded than during the night. The young leaves draw towards the centre of the plant in the evening, so that the horizontal breadth diminishes about 30 per cent. of the daylight breadth; the rising and falling of the leaf-stalks probably exercising some beneficial influence upon the growth.

These turnips were pulled on the 28th December. The large-seed plants numbered 69; their gross weight was 191 lb. 10 oz. ; their net weight 176 lb. 5 oz. ; their average weight, 2 lb. 9 oz. The heaviest bulb weighed 5 lb. 12 oz. ; the ten heaviest, 49 lb. 10 oz. ; and the ten lightest, 10 lb. 3 oz.

The small-seed plants numbered 63 ; their gross weight was 148 lb. 6 oz. ; their net weight, 136 lb. 13 oz. ; their average weight, 2 lb. 2¾ oz. The heaviest weighed 5 lb. 7 oz. ; the ten heaviest, 40 lb. 2 oz. ; the ten lightest, 10 lb. 1 oz.

Experiment 7.—On the 6th June, two large seeds of common turnips, home-grown, were planted in each of six flower pots ; and two small seeds from the same sample in other six pots. The pots were all of the same size, and filled to the same height from the same heap of garden mould, no manure being applied. The seeds were all plump and round. When the seed leaves had cleared the surface, one plant in each pot was clipt off. The fly killed two of the remaining small seeds and one of the large, and more or less damaged others. On the 23d day of their life, a full-size drawing was made in plan, of a large-seeded plant and of a small-seeded (Pl. II. figs. 2 and 3). These drawings may be regarded as examples of the comparative progress made by large and small seeds under seemingly equal external conditions. They were equally watered when necessary, but attained only very small sizes. The roots had been sorely puzzled to provide food, and filled the pots with fibres; one taproot retaining its individuality for a length of more than three feet. One plant was detained a long time in a sickly state from having been crippled of one of its cotyledons, but ultimately outgrew others which the enemy had respected. The five large-seed plants weighed (January 8) 1 lb. ½ oz. ; their net weight was 14½ oz. ; their average weight was 2 9/10 oz. ; the heaviest was 4½ oz.

The four small-seeded weighed 1 lb. ¾ oz. ; their net weight was 14½ oz. ; their average weight 3⅝ oz. ; the heaviest weighing 3⅚ oz.

Experiment 8.—Another experiment in pots was conducted as follows :—On 3d July, large and small white globe seeds, selected from one parcel, were laid in wet cloth to germinate; the intention being to transfer to the pots large and small seeds, which, having pushed out their radicles equal lengths in equal times, were assumed to possess equal vegetative energy. On 5th July, two large embryos were put an inch deep in each of five pots, filled as in the previous case; and two small embryos grown in the same ratio as the large, in each of other five pots. As in the last case, the pots were set beside each other, and all watering was equal for all the pots. No insect touched a leaf, so that the single plants which were left had fair play for the heaviest bulb.

I may notice, in passing, that while the seeds were germinating upon the cloth, I observed that one contained twin embryos. Both the radicles were extended before the cotyledons had broken from the testa. The one was a little larger than the other. They were not joined together at any part. I have also met one case of three cotyledons.

The difference in the tops of these pot plants was very conspicuous from first to last. When twenty-six days old, the aggregate length of leaves of one large-seed plant was 14·2 inches, with a leaf surface (one side) of 9·84 square inches; and of another large-seed plant, the total length of leaves was 9 inches, with a surface of 6·41 square inches; showing, perhaps, that seeds of equal size have not always equal rapidity or capacity of growth. Plants of the same age have also not always the same number of leaves. At the same age one may have seven, another ten and so on. That the capacity of bulbing is different in different plants, independently of manurial or other external conditions, is almost past doubt.

These turnips were taken out of the pots on 8th January. The five large seeds produced a weight of 2 lb. 8½ oz , the net weight being 1 lb. 8½ oz.; and the average weight $4\frac{9}{10}$ oz. The heaviest bulb weighed 13 oz., the lightest, 1½ oz.

Of the five small seeds, the produce was 1 lb. ½ oz.; the net weight was 11¼ oz; the average, $2\frac{3}{10}$ oz. The heaviest weighed 3½ oz.; the lightest, 1¼ oz.

Experiment 9.—This experiment was in a different field from the other field experiments. On 7th June 20 yards of two drills were planted as before described, with large and small green-top yellows; and other 20 yards in continuation, from a different sample of seed; the two sections being regarded as one experiment. The land was newly worked and rather dry. In this and the other cases, the drills had been manured with farm-yard dung and crushed bones for the ordinary crop, without reference to these experiments.

In the present case, the small seed took a good place from the start, and kept it up so persistently, that I felt inclined, looking at the other cases, to think that there had been an accidental superiority in the drill in which they were planted. Eight or ten seeds were dropt into each hole about an inch deep; and as it happened that there was no fly, two or three seeds would have been sufficient. They were singled on 1st July, leaving the largest plant in each hole, or thinning them on the usual method. Some of the plants of both sizes of seed were scarcely out of their cotyledons, while others had permanent leaves of 2 or 3 inches in length; so various are the conditions of germination, not only in different drills, but in half a square inch! As in all the other cases they were weeded, leaving the drills entire.

They were pulled on 22d January. Of large-seed plants there were 152, their gross weight being 390 lb. 4 oz.; their net weight 379 lb. 4 oz.; their average weight 2 lb. 8 oz. The heaviest weighed 5 lb. 14 oz.; the lightest, 4 oz.; the ten heaviest, 49 lb. 3 oz.; the ten lightest, 7 lb. 7 oz.

Of the small-seed plants there were 145; their gross weight was 359 lb. 13 oz.; their net weight 347 lb. 13 oz.; their average weight 2 lb. 6½ oz. The heaviest bulb weighed 5 lb. 10 oz.; the lightest, 4 oz. The ten heaviest weighed 47 lb. 14 oz.; the ten lightest, 8 lb. 5 oz.

I made several other auxiliary experiments which need merely be alluded to. With seeds of swedes of equal size, part of two drills were planted, the one in holes 3 inches deep, the other in holes 1 inch deep. Part of the crop unluckily fell a prey to gallinaceous rapacity; but of the deep planted which remained, the average weighed 1 lb. 8 oz.; the ten heaviest weighing 24 lb. 5 oz.

The average weight of the shallow planted was 2 lb. 2 oz.; the ten heaviest weighing 37 lb. (They were too late for swedes.)

Adjoining drills were singled in various places, leaving in the one the best plants and in the other good plants. In all these the best plants produced the heaviest crop, for which there would be no reason whatever, if the small plant of a small seed could overtake the large plant of a large seed.

I also found that of two adjoining drills, the one reduced as in ordinary hoeing laying bare a great part of the root and cutting many lateral fibres (sometimes a foot in length) while the other drill was left unreduced,—the unreduced yielded the heaviest bulbs.

The interpretation of such experiments as the above is not the easiest part of the work. A few of the bulbs were so rotten that they could not be lifted nor weighed. But as they occurred about equally in both sets of seeds, they do not influence the results; the purpose here not being to find the yield per acre, but to compare individual seeds.

Another point more difficult is the effect on the weight of the crop of double and multiple shaws. I am not aware that the physiological causes of double shaws have been pointed out. Sometimes the main bud between the cotyledons is eaten out, and frequently I have found a little curious spot at the insertion of the cotyledons; and then one or many buds break through in other places; but most frequently secondary buds appear alongside of the primary. Apparently the fleshification of the leaves and leaf-stalks inside the bulb is not sufficiently rapid or regular, so that they force their way as vascular pencils to the outside and become true leaves. Whatever may be the causes, the question here is, does a bulb with three or four tops grow to the same weight as if it had but one? If it does not, then the weight of a double-shawed bulb as compared with the weight of a single-shawed is delusive, whether for comparing different seeds or different manures. There were a good many double-shawed bulbs in these experiments, and this element of uncertainty has not been attempted to be valued but left to neutralise itself in the averages.

The most important figures in the results (see Appendix,

p. 39) are the average weights, and the weights of the 10 heaviest bulbs; and on comparing these for the large and small seeds, it seems conclusively shown, that the large seeds have the advantage. The amount of advantage varies in different cases. Assuming 27-inch drills and plants 9½ inches apart, the advantage in favour of the large seed in experiment 9 is about one ton per acre; the total net weight from the large seed being 27 tons 5 cwt. 3 qrs. 13 lb.; and from the small, 26 tons 5 cwt. 1 qr. 16 lb.; while in experiment 2 the acre-weight, under the same assumptions, would be, from the large seed, 31 tons 4 cwt. 1 qr. 10 lb.; and from the small seed 26 tons 8 cwt. 3 qrs. 7 lb.; showing an advantage in favour of the large of 4¾ tons.

The general conclusion therefore, from these experiments, may be formulated thus:—In any given homogeneous stock of turnip seeds, produced under the same conditions, the larger seeds are in general capable of producing the larger plants.

The question here proposed is, not whether the absolutely largest seeds of different stocks, from transplanted or untransplanted turnips, will yield the largest bulbs (though that remains to be tested), but whether the larger or smaller seeds of a given variety, matured under the same conditions, will yield the largest bulbs? The above experiments show, that while frequently a small seed does in ordinary but unknown circumstances produce a larger bulb than a large seed, yet, on an average, large seeds have the advantage. They have a larger cotyledonary store to feed upon before touching manure. It is the same with other seeds. Of two equal wheat kernels, if the half of the one is cut off while the other is left entire, the entire kernel will throw out nearly three times as many tillers as the cut kernel. (*Author's experiments.*)

The foregoing paper suggests the following remarks. We see that there are certain botanical conditions of which advantage may be taken by agriculture. In connection with the Highland Society and other Agricultural Societies we have lately heard a good deal about Agricultural Chemistry. But we never hear anything of Agricultural Botany.

It is taken for granted that the seeds of the farm are perfectly indifferent. Provided plenty of manure is put into soil, the intimate laws and habits of the seeds and plants to be grown may be ignored; the result will be proportional solely to the manure. Pap of all sorts has been manufactured regardless of cost; feeding-bottles of the most attractive design have been presented; but whether the child, Flora's little pale sprawling embryo, should have its head or its heels uppermost, has been mostly regarded as immaterial.

Now, the production of certain plants is the chief object of agriculture. A full discussion, therefore, of the biology of these plants is primarily demanded before chemistry can be intelligently enlisted. It is not here denied that much is already known, both formally and instinctively; but it can hardly be denied that Agricultural Botany has been somewhat left behind. The above experiments show that chemistry cannot announce the full verdict of nature; the botanical members of the jury must no longer be disregarded. In fact, the true position of Agricultural Chemistry is that of handmaid to Agricultural Botany. In this relationship the two have yet a wide field for harmonious conquest.

There is an unscientific spirit abroad teaching that no experiments are of any value unless they can bring an augmentation to the supply of food. But true experiments are for finding the constitution of nature, that life may train itself into harmony therewith; and an experiment which proves that in any direction, under existing knowledge, a limit has been reached, is as valuable a lesson as an experiment which announces another ton upon the acre.

The time has probably come when we must be content with small advances and diminishing profits. We have all heard of the botanical benefactor who makes two blades of grass to grow where one grew before: but the value of such a benefaction depends on its cost. If the new blade costs a halfpenny and sells for a farthing, it will be left to wither. It is only upon rare occasions that a second blade can be introduced by pure intellect, free of all charge. It is one province of Agricultural Botany to find out those biological conditions in which a plant is able most fully to appropriate the gratis stores of nature. If a large turnip seed grows a larger turnip, entirely by draughts upon the manures supplied, it is a calculation whether its use is an improvement or not; but if a part of the larger bulk is derived from atmospheric elements, we have an advantage of that order which costs nothing.

In view of the considerations thus suggested, I make bold to think that the chief Botanical Society in Scotland ought to take measures for giving a more prominent position to Agricultural Botany than it has hitherto occupied.

APPENDIX.

Expt.	Average of Large Seeds.		Average of Small Seeds.		Heaviest 10 of Large Seeds.		Heaviest 10 of Small Seeds.		Dif. of Aver. Weight.
	lb.	oz.	lbs.	oz.	lb.	oz.	lb.	oz.	oz.
2	2	13¾	2	6¾	53	6	47	8	7
2-*a*	2	14	2	5½	48	6	42	12	8½
3	2	0	1	5	36	10	27	2	11
4	1	15	1	12¾	33	5	29	15	2¼
5	2	10¼	2	1	44	14	38	4	9¼
6	2	9	2	2¾	49	10	40	2	6¼
9	2	8	2	6½	49	3	47	14	1½
Aver.	2	7	2	1¼	45	1	39	1	6½

V. *Remarks on Professor E. Morren's Views of Vegetable Digestion.* By I. BAYLEY BALFOUR, Sc.D., M.B., F.L.S.

(Read 8th March 1877.)

Professor Morren, of Liege, has recently published a paper on the subject of vegetable digestion as a supplement to his well-known observations on carnivorous plants.

The object of the paper is to show that digestion is not a function peculiar to the so-called carnivorous plants, but is a universal process in all living beings, vegetable as well as animal, and that the facts narrated of the carnivorous plants, though doubted by many, are yet quite in accordance with the general theory of plant nutrition. Digestion, he seeks to show, is necessary for and precedes assimilation.

Animal digestion is essentially a process of fermentation,